Environmental impacts of the control with organophosphate pesticides and explosions of the red-billed quelea bird *Quelea quelea* in Africa

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Abstract

Both spraying with pesticides and using explosions to kill red-billed quelea (*Quelea* quelea) may affect non-target organisms and leave hazardous contaminants in the environment. Results of monitoring such effects in Botswana and Tanzania showed that although few non-target mortalities were noted, indirect effects in terms of depressed cholinesterases in birds and small mammals were marked and pesticides and contaminants from products used for the explosions persisted at controlled sites at unacceptable levels and for long periods (at least 188 days for sprays and at least 11 months for petroleum products and plastics).

Keywords: cholinesterases, explosions, non-target organisms, organophosphate sprays, *Quelea quelea* L., red-billed quelea, residues

Introduction

The red-billed quelea *Quelea quelea* is a major pest of small grain cereals in sub-Saharan Africa (Bruggers and Elliott, 1989). The birds nest colonially and also roost in dense concentrations, providing targets that can be controlled by spraying with organophosphate avicides, such as fenthion and cyanophos, or by explosives. Some environmental impacts of these lethal methods used against *Q. q. lathamii* in Botswana and *Q. q. aethiopica* in Tanzania were investigated. Mortalities of non-target organisms were recorded after control operations. The blood cholinesterase levels of non-target birds and small mammals were monitored and soil residue analyses were conducted on samples after sprays with fenthion or cyanophos and after explosions. Pesticide droplet sizes and deposition were also studied.

Materials and methods

(a) *Sprayed sites*. Soil samples of approximately 200 g (maximum depth 10 cm) were collected at 7 sprayed sites in Botswana and 4 in Tanzania and residues of fenthion or cyanophos detected by GCMS. As blood cholinesterases are depressed by the action of organophosphates, we used custom-made field kits using the Ellman reaction (Ellman et al., 1961, Test-mate kits, EQM Research Inc., Cincinnati, USA) to analyse erythrocyte cholinesterase (acetylcholinesterase, AChE) and plasma cholinesterase (butyrylcholinesterase, PChE) levels in the blood of birds and small mammals caught before and after spraying. Droplet samples were collected on magnesium oxide (MgO) coated glass slides placed on metal sampling masts 1 m above ground level. (b) *Sites of explosions*. Soil samples were collected at 10 sites in Botswana before and after explosions of diesel and petroleum mixtures in plastic containers and levels of total petroleum hydrocarbons and plastics were detected by GCMS. Any dead non-targets were recorded and effects on the vegetation assessed visually.

Results

Spraying operations' effects on non-target birds were confirmed by direct associations between non-target morbidity and the depression of blood cholinesterase levels by as much as 90%. Small mammal populations examined 6 weeks after aerial sprays in northern Botswana had significantly reduced blood cholinesterases. Fenthion had a half life of 47 days in soil, sometimes remaining at unacceptably high

levels (11.7 µg/g) for up to at least 188 days. Both soil analyses and pesticide droplet analyses showed that the distribution of fenthion was very uneven at sites sprayed in Botswana. The droplets per cm^2 were nearly always below the recommended value of 44 which, together with other operational problems, such as excessively high droplet volume median diameters, lower than recommended numerical median diameters and poorly positioned spray nozzles, led to poor quelea kills. With one exception due to a misidentification of the target birds, no excessive non-target mortalities were noted out of all of the control methods monitored. Small mammals were the most numerous victims of explosions, after which both residues of petroleum products (up to 131 µg/g of total petroleum hydrocarbons, TPH; mean=7.51, SD=22.13, n=43) and plastics (up to 3.2 µg/g of total phthalates; mean=0.32, SD=0.61, n=43) were detected in soil samples. The mean concentrations for TPHs and phthalates were, respectively, 49 and 9 times greater than background levels and likely to be responsible for ecological disruption including secondary poisoning. The explosions also damaged the soil by leaving craters covering >1% of the controlled areas, where the highest concentrations of hydrocarbons and phthalates were found, and led to burnt vegetation. However, the plants involved recovered within 1 year unless their trunks were split. Residues of TPHs (up to 1.3 µg/g) and of phthalates (up to 0.854 µg/g) were still present 11 months after explosions.

Discussion

Although fewer non-target mortalities were recorded than expected on the basis of other studies (McWilliam and Cheke, 2004), the environmental effects were nevertheless unacceptable in terms of soil residues and morbidity of wildlife. Recommended mitigation measures for explosions include (a) removing plastic remains of petroleum product containers for disposal at safe containment facilities rather than burning them in situ after explosions; (b) investigating the possibility of replacing the plastic containers used for the explosions with 'tetra pack' cartons; for ground sprays (c) ensuring that cut-line orientation and layout is conducted with knowledge of the prevailing wind direction and wind speed to minimize human health and environmental impacts; (d) ensuring that all spraying equipment is serviced, calibrated and well maintained; (e) ensuring that sprayer calibration is performed at regular intervals and includes droplet analysis to ensure proper pesticide deposition; (f) ensuring that appropriate droplet calibration is performed for each type of pesticide formulation to be used; for aerial sprays (g) satellite navigation systems should be available; (h) target sites should be marked clearly and indicate where within the target site the spray swaths are required; (i) two way radios (VHF and CB) could aid in demarcating the layout of target areas if the pilot is enabled to contact the ground crew for important visual information; for both explosions and sprays (j) removing dead quelea and other carcasses after control operations and disposing of them in safe containment facilities; (k) wearing of protective gear during control operations; (l) training in bird identification methods to ensure that only quelea birds are targeted; (m) consider using mass-trapping in cases where this could serve as a control measure and provide food.

References

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